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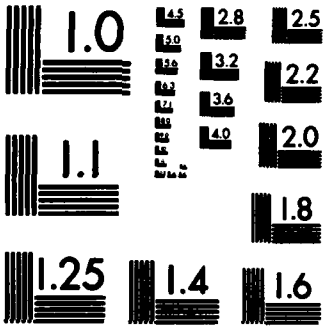

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This technical report consists of a description of the work done in the Washington University Behavior Research Laboratories supported by the AFOSR. The text describes the hardware assembled for the proposed studies and the software which has been developed for stimulus presentation and execution. The study format is described as well as some preliminary results bearing on the issues to be addressed.

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PROGRESS REPORT

A PSYCHOPHYSIOLOGICAL MAPPING OF COGNITIVE PROCESSES

Contract F49620-83-C-0059

Department of the Air Force

Air Force Office of Scientific Research (AFSC)

Bolling Air Force Base, DC 20332

March 1, 1983 through February 29, 1984

Dr. Alfred R. Fregly
Life Sciences Directorate
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A-1

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Report date: May 4, 1984

1.0 Introduction

The basis of this effort lies in the assumption that cognitive processes, as all bodily processes, are reflected in some appropriate set of physiological indices. While the evidence is abundant that physiological variables are altered by such processes, less information is available concerning the differentiation of cognitive processes from a psychophysiologically multivariate perspective. We can not expect that the number of dimensions available in most single measures could provide us with more than a rather gross picture of cognitive activities. Though it is not unusual for several measures to be taken simultaneously it is typical in such psychophysiological studies, that each measure is analyzed separately for it's relationship to the inferred process(es) rather than entered into an analysis wherein unique patterns of measures are associated with logically and empirically distinguishable cognitive events. That is the task set by the present effort.

2.0 Methods

2.1 Apparatus

The present apparatus (figure 1) differs somewhat from that outlined in the contract proposal in order to accommodate an alteration in the experimental strategy. Each of the units (numbered 1 through 7) can display up to 20 alphanumeric or nonsense characters which appear in a 1 cm wide clear horizontal strip in an otherwise flat black 24" curved screen (not shown) shielding the display hardware. Finger responses of the subject to the stimuli are fed to the computer (LSI 11/23) and are

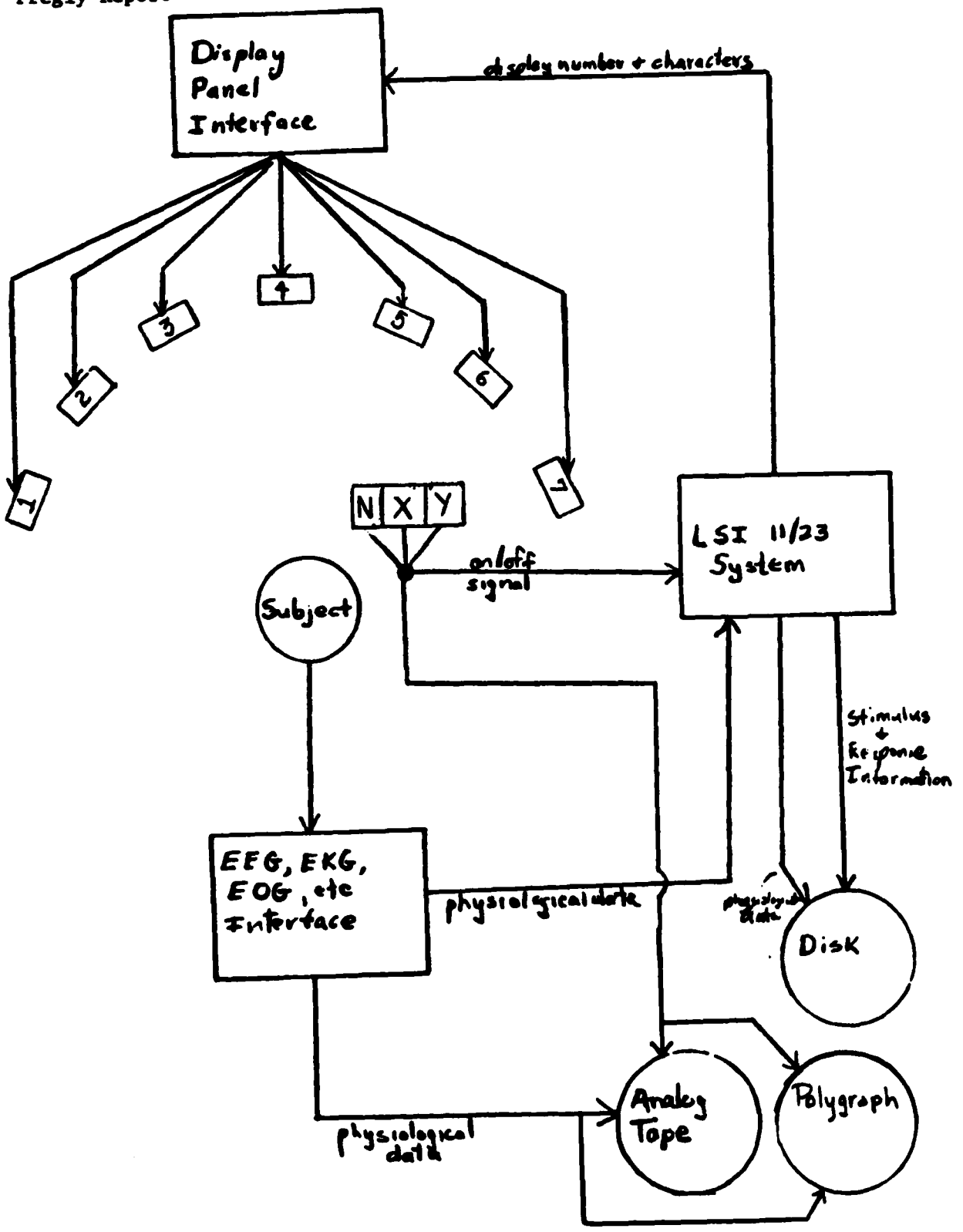

Figure 1. Apparatus and stimulus and response flow chart.

simultaneously recorded on analog tape. A polygraph write-out from the analog tape output is provided as well, to monitor the subject and the integrity of the entire system. Physiological signals follow the same path as finger responses.

2.2 Computer Software

Stimulus control software for this configuration has been developed and has been used to collect some preliminary data. This software consists of

2.2.1 Stimulus generation programs: This is a very flexible package which allows for the construction of a stimulus sequence. This sequence may consist of up to 300 unique or (optionally) repeated trials. Each trial may consist of up to 10 events where an "event" is any change (onset/offset) of conditions. Thus up to 5 "stimuli" may be presented in any temporal sequence, and for any duration, on a trial, where a "stimulus" may be any number of characters up to 20 presented simultaneously. This sequence may be edited in the process of construction.

2.2.2 Execution: The stimulus sequence generated above may then be executed on the alphanumeric display. While in execution this program is interactive with the subject in that his response may be used to terminate a pause and initiate an interstimulus interval. In view of the fact that these programs have been designed to be general, we anticipate that they will serve all experiments in this contract.

2.2.3 Physiological responses: Our plan is to digitize and store the physiological data on-line (with analog tape backup). These programs are nearing completion. They are designed to acquire up to 16 channels of data digitizing each at a 5 msec sampling rate. Shortly, sampling

rate will be independent for each channel in order to cut down on storage space allocated to those signals (eg., EKG) that do not require sampling at that rapid rate. At present we do not intend to utilize the full capacity of this system, restricting our input to 7 channels.

2.2.4 Filtering: These programs will be utilized offline, during data reduction, and will consist of a menu from which one can select the filtering appropriate to a particular signal. Programs for these are available.

2.3 Preliminary data

The experimental apparatus, stimulus generation and execution programs are on-line and have been used to collect some preliminary data but only in conjunction with EOG and head movement parameters.

2.3.1 Item recognition: These data were collected under simplified conditions where a single character was presented in the center of the display followed by a second, test letter. Subjects were required to judge whether the second stimulus was a member of the (single character) memory set. Further, the position of the test stimulus was varied in one of four locations, two on either side of midline.

The latency of saccade termination to the peripheral stimuli was related to the reaction time for a match/mismatch judgment with respect to the memory and test stimuli. Data indicate that there exists a stronger relationship between the time to fixate a peripheral stimulus and reaction time to that stimulus when the stimulus is closer to the central (memory) stimulus than when it is distal. Thus, the time required to make a comparison judgment about a stimulus, given that the eye is already fixating that stimulus, is dependent, in part, on the distance the eye has previously

transversed in the course of fixating it, a result which is not intuitively predictable. It is possible that variation in another component of reaction time is the basis of this. If latency to saccade onset were more variable in the distal condition, this might introduce the noise in the RT measure which reduced the correlation. The data do suggest that the latency of saccade onset is greater for the more peripheral stimuli. Whether greater variability accompanies the longer latencies is a matter to be determined by further analyses of these data.

2.3.2 Location of eyeblinks in a task context: Other data collected in this period bear on the relevance of blink parameters to the procedure described below. These data were taken in a task wherein subjects were required to discriminate between two tones differing in duration. It was found that blink latency, i.e., time from stimulus offset to blink onset, was smaller for longer tones than for shorter tones. This confirmed observations made on previous data. Though in earlier data, response requirements (to the shorter tone only) were confounded with tone duration, these were counterbalanced in the later study with essentially the same results. The hypothesis we entertain to explain this phenomenon is that blinks occur following the completion of some cognitive process, in this case a decision process. Thus, for the shorter stimulus, the decision process cannot begin until after the stimulus ends. For the longer stimulus, in contrast, the decision process can be initiated while the stimulus is still on. This is at the point during this stimulus where it exceeds the shorter one by some noticeable amount. Measured from stimulus offset, then, the blink latency would be shorter than on short stimulus trials. This conceptualization allows us to predict, in the procedure described below, when blinks can

be expected to occur or, turning this around, allows us to use the blink as informative of the state of cognitive activity.

2.4 Procedure

The procedure we have developed for the first study follows a modified Sternberg paradigm. The subject commits a set of characters to memory and is then presented with a test stimulus and asked to judge whether the test stimulus is a member of the memory set. In our case a trial consists of a sequence of three stimulus presentations.

2.4.1 Stimulus sequence: S1 is a single numeral (0.6") which corresponds to the number of characters in the next presentation.

Six seconds after S1, the memory set (S2) is presented. The letters in this set, which varies in size from trial to trial, are presented simultaneously. This represents a departure from the usual Sternberg procedure wherein memory set stimuli are presented sequentially. In the typical Sternberg paradigm, letters are presented sequentially at intervals of, for example, 1 sec. Each letter (but the first) would normally be encoded, integrated with the encoded prior letters and rehearsed in the interval before the next letter is presented. We might anticipate, under these circumstances, that the ERP to each letter would reflect either the encoding of a (that) single letter or be confounded by the additional processes described. Although the ERP response to simultaneous presentation may contain elements of the latter processes, it will reflect the encoding of the entire set at once and it is for this purpose that it has been chosen.

Again, after a 6" delay, a single character, S3, is presented which may ($p = 0.5$) or may not be a member of the memory set. The subject is

asked to indicate which is the case. Completion of the response initiates a final 6" interval terminating in S1 for the following trial.

2.4.2 Set size: Set sizes tentatively will be 1, 3, and 5. Preliminary data indicate that 650 msec is adequate, though just so, for acquisition of 5 characters, simultaneously presented. Set size is included as a variable to confirm the presumed observation that the physiological pattern evoked by the memory set is unique to the encoding process. If so, then variation in set size should be reflected in concomitant variation in those very characteristics which distinguish the pattern from that associated with other processes. In view of this, we are currently exploring set sizes beyond 5 hoping that inclusion of these would, by taxing the encoding process, more likely allow a test of the above hypothesis. This will entail exposure durations of greater than 650 msec which might provoke self-defeating saccades. This will be ascertained in the pilot study.

2.5 Probe Event-Related Potentials

In addition to the ongoing EEG and the ERP's to the three stimuli described, we have introduced "probe" ERPs. These are ERP responses to stimuli which are irrelevant to the task at hand but to the extent that they draw on processing capacity (neural circuitry) utilized by the focal task are altered in shape. Thus, they are informative in a "negative" way. Such probes will be inserted in the S1-S2 and S2-S3 intervals at specific, but unpredictable locations.

3.0 Prospective

We anticipate that the contract software will be completed at approximately the same time as the parametric details have been worked out. At that point, the main experiments will proceed concurrent with the development of reduction programs for data handling.


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